Edited by Birgit Kamm,
Patrick R. Gruber, Michael Kamm

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Biorefineries – Industrial Processes and Products

Status Quo and Future Directions
Volume 1

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The Editors

Dr. Birgit Kamm
Research Institute
Bioactive Polymer Systems
biopos e.V.
Kantstr. 55
14513 Teltow
Germany

Dr. Patrick R. Gruber
President and CEO
Outlast Technologies Inc.
5480 Valmont Road
Boulder, CO 80301
USA

Michael Kamm
Biorefinery.de GmbH
Stiftstr. 2
14471 Potsdam
Germany

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Editor's Preface

In the year 2003 when the idea for this set of books "Biorefineries, Biobased Industrial Processes, and Products" arose, the topic of biorefineries as means of processing industrial material and efficient utilization of renewable products had been primarily a side issue beyond the borders of the United States of America. This situation has changed dramatically over the last two years. Today in almost every developed and emerging nation much work is being conducted on biorefinery systems, driven by the rising cost of oil and the desire of to move away from petrochemical-based systems.

In these books we do not claim to describe and discuss everything that belongs or even might belong to the topic of biorefineries – that would be impossible. There are many types of biorefinery, and the state of the technology is changing very rapidly as new and focused effort is directed toward making biorefineries a commercial reality. It is a very exciting time for those interested in biorefineries – technologies for bio-conversion have advanced to a state in which they are becoming practical on a large scale, economics are leaning more favourably to the direction of renewable feedstocks, and chemical process knowledge is being applied to biobased systems.

As the editors of the first comprehensive biorefinery book we saw it as our duty to provide, first of all, a general framework for the subject – addressing the main issues associated with biorefineries, the principles and basics of biorefinery systems, the basic technology, industrial products which fall within the scope of biorefineries, and, finally, technology and products that will fall within the scope of biorefineries in the future.

To provide a reliable description of the state of biorefinery research and development and of industrial implementations, strategies, and future developments we asked eighty-five experts from universities, research and development institutes, and industry and commerce to present their views, their results, their implementations, and their ideas on the topic. The results of their contributions are thirty-three articles organized into seven sections. Our very special thanks go to all the authors.

We are especially indebted to Dr. Hubert Pelc from Wiley-VCH publishing, who worked with us on the concept and then, later, on the development and implementation of the book. Thanks go also to Dr. Bettina Bems from Wiley-

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VCH publishing, who managed with admirable professionalism and very much patience, and to the three editors and eighty-five authors from three different continents. We are also indebted to Hans-Jochen Schmitt, also of Wiley-VCH publishing, who had the not always easy task of arranging the manuscripts in a form ready for publication.

Maybe in 2030, when a biobased economy utilizing biorefinery technology has become a fundamental part of national and globally connected economies, someone will wonder what had been thought and written about the subject of biorefineries at the beginning of the 21st century. Hopefully this book will be highly representative. Until then we hope it will contribute to the promotion of international biorefinery developments.

Teltow-Seehof (Germany)
Boulder, CO (USA)
Potsdam (Germany)

Birgit Kamm
Patrick R. Gruber
Michael Kamm

November 2005

Foreword

One-hundred-and-fifty years after the beginning of coal-based chemistry and 50 years after the beginning of petroleum-based chemistry industrial chemistry is now entering a new era. In the twenty-first century utilization of renewable raw materials will gain importance in the chemical conversion of substances in industry. Partial or even complete re-adjustment of whole economies to renewable raw materials will require completely new approaches in research, development, and production. Chemical and biological sciences will play a leading role in the building of future industries. New synergies between biological, physical, chemical, and technical sciences must be elaborated and established and special requirements will be placed on raw material and on product-line efficiency and sustainability. The necessary change from chemistry based on a fossil raw material to biology-based modern science and technology is an intellectual challenge for both researchers and engineers. Chemists should support this change and collaborate closely with their colleagues in adjoining disciplines, for example biotechnology, agriculture, forestry, and the material sciences.

The German Chemical Society will help direct this necessary development by supporting within its structure new kinds of organization for chemists to work on this subject in universities, research institutes, and industry.

This two-volume book is based on the approach developed by biorefinery-systems – transfer of the logic and efficiency of today's petrochemical product lines and product family trees into manipulation of biomass. Raw biomass materials are mechanically separated into substances for chemical conversion into other products by different methods, which may be biotechnological, thermochemical, and thermal. Review of biomass processes and products developed in the past but widely forgotten in the petroleum age will be as important as the presentation of new methods, processes, and products that still require an enormous amount of research and development today.

Henning Hopf
President of the German Chemical Society
Frankfurt (Germany)

November 2005

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Foreword

On October 5, 2005, the Nobel Prize Committee made an interesting and important statement with regard to the prize in chemistry. It said, "This represents a great step forward for 'green chemistry', reducing potentially hazardous waste through smarter production. [This research] is an example of how important basic science has been applied for the benefit of man, society and the environment." By making this statement, the Nobel committee recognized what a new generation of scientists has known for quite some time, that by working at the most fundamental level – the molecular level – we are able to design our products, processes, and systems in ways that are sustainable.

There is general recognition that the current system by which we produce the goods and services needed by society is not sustainable. This unsustainability takes many forms. It would be legitimate to note that in our current system of production we rely largely on finite feedstocks extracted from the Earth that are being depleted at a rate that cannot be sustained indefinitely. It is equally legitimate to recognize that our current production efficiency results in more than 90% of the material used in the production process ending up as waste, i.e. less than 10% of the material ends up in the desired product. Yet another condition of unsustainability is in our current energy use; this not only relies largely on finite energy sources but also results in degradation of the environment that cannot be continued as the growing population and demands of the developing world emerge over the course of the twenty-first century. Finally, the products and processes we have designed since the industrial revolution have accomplished their goals without full consideration of their impact and consequence on humans and the biosphere, with many examples of toxic and hazardous substances being distributed throughout the globe and into our bodies.

If we are to change this unsustainable path, it will need the direct and committed engagement of our best scientists and engineers to design the future differently from the past. We will need to proceed with a broader perspective such that when we design for efficiency, effectiveness, and performance, we now must recognize that these terms include sustainability – a minimized impact on humans and the environment.

An essential part of meeting the challenge of designing for sustainability will be based on the nature of the materials we use as starting materials and feedstocks. Any sustainable future must ensure that the materials on which we base

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our economic infrastructure are renewable rather than depleting. The rate of renewability is also important because certainly one could argue that petroleum is renewable if you have a few million years to wait. Serious analysis would, however, necessitate that the rate of renewability is connected to the rate of use. There are options for how to approach this technological challenge, for example using waste products from one process as a feedstock for another, that are well thought through in industrial ecology models. There is, however, recognition that an essential part of a sustainable future will be based on appropriate and innovative uses of our biologically-based feedstocks.

This book addresses the essential questions and challenges of moving toward a sustainable society in which bio-based feedstocks, processes, and products are fundamental pillars of the economy. The authors discuss not only the important scientific and technical issues surrounding this transition but also the necessary topics of economics, infrastructure, and policy. It is only by means of this type of holistic approach that movement toward genuine sustainability will be able to occur where the societal, economic, and environmental needs are met for the current generation while preserving the ability of future generations to meet their needs.

While it will be clear to the reader that the topics presented in this book are important, it is at least as important that the reader understand that these topics – and the transition to a sustainable path that they address – are urgent. At this point in history it is necessary that all who are capable of advancing the transition to a more sustainable society, engage in doing so with the level of energy, innovation, and creativity that is required to meet the challenge.

Paul T. Anastas
Director of the Green Chemistry Institute
Washington, D.C.

November, 2005

List of Contributors (Volume 1 and 2)

José A. M. Agnelli
Universidade Federal de São Carlos
Departamento de Engenharia
de Materiais
Rodovia Washington Luis (SP-310)
São Carlos, São Paulo
Brazil

Margrethe Andersen
AgroFerm A/S
Limfjordsvej 4
6715 Esbjerg N
Denmark

Rolf Bachmann
McKinsey and Company Inc
Zurich Office
Alpenstrasse 3
8065 Zürich
Switzerland

Ursula Biermann
Fachbereich Chemie
Carl von Ossietzky Universität
Oldenburg
Postfach 2603
26111 Oldenburg
Germany

Robert C. Brown
Center for Sustainable Environmental
Technologies
Iowa State University
286 Metals Development Building
Ames, IO 50011
USA

Gösta Brunow
Department of Chemistry
University of Helsinki
A. I. Virtasen aukio 1
00014 Helsinki
Finland

Stefan Buchholz
Degussa AG
Creavis
Projecthouse ProFerm
Rodenbacher Chaussee 4
63403 Hanau-Wolfgang
Germany

Rainer Busch
Dow Deutschland GmbH & Co. OHG
Industriestrasse 1
77836 Rheinmünster
Germany

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Grant M. Campbell
Satake Centre for Grain Process Engineering
School of Chemical Engineering and Analytical Science
The University of Manchester
Sackville Street
Manchester M60 1QD
UK

Joel R. Cherry
Novozymes Biotech Inc
1445 Drew Ave
Davis, CA 95616
USA

Gopal Chotani
Genencor International
925 Page Mill Road
Palo Alto, CA 94304
USA

L. Davis Clements
Renewable Products Development Laboratories
3114 NE 45th Ave.
Portland, OR 97213
USA

Bruce E. Dale
Department of Chemical Engineering and Materials Science
Michigan State University
East Lansing, MI 48824
USA

Bill Dean
Genencor International
925 Page Mill Road
Palo Alto, CA 94304
USA

Tim Dodge
Genencor International
925 Page Mill Road
Palo Alto, CA 94304
USA

Donald L. Van Dyne
Agricultural Economics
University of Missouri – Columbia
214c Mumford Hall
Columbia, MO 65211
USA

Wolter Elbersen
Agrotechnology and Food Innovations B.V.
P.O. Box 17
6700 AA Wageningen
The Netherlands

Steve Fitzpatrick
Biofine
245 Winter Street
Waltham, MA 02154
USA

Paul Fowler
The BioComposites Centre
University of Wales
Bangor
Gwynedd LL57 2UW
UK

Wolfgang Friedt
Institut für Pflanzenbau und Pflanzenzüchtung 1
Justus-Liebig-Universität Giessen
Heinrich-Buff-Ring 26–32
35392 Giessen
Germany

John Frye
Pacific Northwest National Laboratory
P.O. Box 999/K2-12
Richland, WA 99352
USA

Patrick R. Gruber
President and CEO
Outlast Technologies Incorporated
5480 Valmont Road
Suite 200
Boulder, CO 80301
USA

Dietmar R. Grüll
Südzucker Aktiengesellschaft
Mannheim/Ochsenfurt
Wormser Strasse 11
67283 Obrigheim/Pfalz
Germany

Daniel J. Hayes
Department of Chemical
& Environmental Sciences
University of Limerick
Limerick
Ireland

Michael H.B. Hayes
Department of Chemical
& Environmental Sciences
University of Limerick
Limerick
Ireland

David E. Henton
Nature Works LLC
(former Cargill Dow LLC)
15305 Minnetonka Blvd
Minnetonka, MN 55345
USA

James R. Hettenhaus
CEA Inc
3211 Trefoil Drive
Charlotte, NC 28226
USA

Karlheinz Hill
Cognis Deutschland GmbH & Co. KG
Paul-Thomas-Straße 56
40599 Düsseldorf
Germany

Thomas Hirth
Fraunhofer-Institut
Chemische Technologie
Joseph-von-Fraunhoferstraße 7
76327 Pfinztal
Germany

John Holladay
Pacific Northwest National Laboratory
P.O. Box 999/K2-12
Richland, WA 99352
USA

Franz Jetzinger
Zuckerforschung Tulln
Gesellschaft mbH
Josef-Reither-Strasse 21–23
3430 Tulln
Austria

Donald L. Johnson
Biobased Industrial Products
Consulting
29 Cape Fear Drive
Hertford, NC 27944
USA

Ed de Jong
Agrotechnology and
Food Innovations B.V.
P.O. Box 17
6700 AA Wageningen
The Netherlands

Birgit Kamm
Research Institute Bioactive Polymer Systems (biopos e.V.)
Research Centre Teltow-Seehof
Kantstraße 55
14513 Teltow
Germany

Michael Kamm
Biorefinery.de GmbH
Stiftstraße 2
14471 Potsdam
Germany
and
Laboratories Teltow
Kantstraße 55
14513 Teltow
Germany

Raphael Katzen
9220 Bonita Beach Road
Suite 2000
Bonita Springs, FL 34135
USA

Ralf Kelle
Degussa AG
R & D Feed Additives
Kantstrasse 2
33790 Halle/Westfalen
Germany

Pauli Kiel
Biotest Aps
Gl. Skolevej 47
6731 Tjæreborg
Denmark

Seungdo Kim
Department of Chemical Engineering and Materials Science
Michigan State University
East Lansing, MI 48824
USA

Apostolis A. Koutinas
Satake Centre for Grain Process Engineering
School of Chemical Engineering and Analytical Science
The University of Manchester
Sackville Street
Manchester M60 1QD
UK

Martin Kozich
Zuckerforschung Tulln
Gesellschaft mbH
Josef-Reither-Strasse 21–23
3430 Tulln
Austria

George A. Kraus
Department of Chemistry
Iowa State University
1605 Gilman Hall
Ames, IA 50011-3111
USA

Thomas C. Kripp
Wella AG
Abt. FON
Berliner Allee 65
64274 Darmstadt
Germany

Stefan Kromus
BioRefSYS-BioRefinery Systems
Innovationszentrum Ländlicher Raum
Auersbach 130
8330 Feldbach
Austria

Siegmund Lang
Institut für Biochemie
und Biotechnologie
Technische Universität
zu Braunschweig
Spielmannstraße 7
38106 Braunschweig
Germany

Frieder W. Lichtenthaler
Institute of Organic Chemistry
Darmstadt University of Technology
Petersenstraße 22
64287 Darmstadt
Germany

Wilfried Lühs
Institut für Pflanzenbau
und Pflanzenzüchtung 1
Justus-Liebig-Universität Giessen
Heinrich-Buff-Ring 26–32
35392 Giessen
Germany

Guido Machmüller
FB 9 – Organische Chemie
Bergische Universität
GH Wuppertal
Gaußstraße 20
42097 Wuppertal
Germany

Paulo E. Mantelatto
Centro de Tecnologia Canavieira
(formerly Centro de Tecnologia
Copersucar)
Fazenda Santo Antonio
CP 162
13400-970 Piracicaba
Brazil

Achim Marx
Degussa AG
Creavis
Projecthouse ProFerm
Rodenbacher Chaussee 4
63403 Hanau-Wolfgang
Germany

Jürgen O. Metzger
Fachbereich Chemie
Carl von Ossietzky Universität
Oldenburg
Postfach 2603
26111 Oldenburg
Germany

Michael Narodoslawsky
Graz University of Technology
Institute of Resource Efficient and
Sustainable Systems (RNS)
Inffeldgasse 21 B
8010 Graz
Austria

Jefter Nascimento
PHB Industrial SA
Fazenda da Pedra
s/n – C. Postal 02
CEP 14150 Servana
São Paulo
Brazil

Glenn E. Nedwin
Novozymes Biotech Inc
1445 Drew Ave
Davis, CA 95616
USA

Ulf Prüße
Federal Agricultural Research Centre (FAL)
Institute of Technology and Biosystems Engineering
Bundesallee 50
38116 Braunschweig
Germany

E. Kendall Pye
Lignol Innovations Corp.
3650 Westbrook Mall
Vancouver, BC
V6S 2L2
Canada

René van Ree Rea
Energy research Centre of the Netherlands (ECN) – Biomass Department
P.O. Box 1
1755 ZG Petten
The Netherlands

Julia Richter
Institut für Chemie
Universität Potsdam
Karl-Liebknecht-Str. 24–25
14476 Golm
Germany

Jens Riese
McKinsey and Company Inc
Munich Office
Prinzregentenstraße 22
80538 München
Germany

Julian R.H. Ross
University of Limerick
Department of Chemical & Environmental Sciences
Limerick
Ireland

Carlos Eduardo Vaz Rossell
Centro de Tecnologia Canavieira (formerly Centro de Tecnologia Copersucar)
Fazenda Santo Antonio
CP 162
13400-970 Piracicaba
Brazil

Mark Rüsch gen. Klaas
Department Technology
University of Applied Sciences Neubrandenburg
Brodaer Straße 2
17033 Neubrandenburg
Germany

Hans J. Schäfer
Organisch-Chemisches Institut
Universität Münster
Corrensstraße 40
48149 Münster
Germany

Daniel J. Schell
National Bioenergy Center
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393
USA

Matthias Schmidt
Biorefinery.de GmbH
Stiftstraße 2
14471 Potsdam
Germany

Manfred P. Schneider
FB 9 – Organische Chemie
Bergische Universität
GH Wuppertal
Gaußstraße 20
42097 Wuppertal
Germany

Margit Schulze
FB Angewandte Naturwissenschaften
FH Bonn-Rhein-Sieg
Grantham-Allee 20
53754 Sankt Augustin
Germany

Mathias O. Senge
SFI Tetrapyrrole Laboratory
School of Chemistry
Trinity College Dublin
Dublin 2
Ireland

Jack Starr
Cargill Dow LLC
15305 Minnetonka Blvd
Minnetonka, MN 55345
USA

Sarah A. Teter
Novozymes Biotech Inc
1445 Drew Ave
Davis, CA 95616
USA

Johan Thoen
Dow Europe GmbH
Bachtobelstrasse 3
8810 Horgen
Switzerland

Mette Hedegaard Thomsen
Risø National Laboratory
Biosystems Department
Frederiksbovgvej 399
4000 Roskilde
Denmark

Jeffrey S. Tolan
Iogen Corporation
8 Colonnade Road
Ottawa
Ontario K2E 7M6
Canada

Robert van Tuil
Agrotechnology and Food Innovations
B.V.
P.O. Box 17
6700 AA Wageningen
The Netherlands

Dan W. Urry
BioTechnology Institute
University of Minnesota
Twin Cities Campus
1479 Gortner Avenue
Suite 240
St. Paul, MN 55108-6106
USA
and
Bioelastics Inc.
2423 Vestavia Drive
Vestavia Hills, AL 35216-1333
USA

Fernando Valle
Genencor International
925 Page Mill Road
Palo Alto, CA 94304
USA

Klaus-Dieter Vorlop
Federal Agricultural Research Centre
(FAL)
Institute of Technology and
Biosystems Engineering
Bundesallee 50
38116 Braunschweig
Germany

Rouhang Wang
Satake Centre for Grain Process
Engineering
School of Chemical Engineering and
Analytical Science
The University of Manchester
Sackville Street
Manchester M60 1QD
UK